Replacement of the A∅ laser oscillator

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The present oscillator that drives the A∅ laser is home-made using a Quantronix 112 head with a YLF:Nd rod. The technology is twenty years old and the laser has been in operation for more than 10 years. The intrinsic width of the output pulses is 60-120 ps but the pulse is stretched in a 2.2 km single mode fiber to give it additional bandwidth. The resulting longer pulse length ($\sim$240 ps) allows for amplification to high power levels in glass:Nd amplifiers, and eventually compression to 1-2 ps.

This system is by far not optimum for use in the photoinjector. It is also difficult to maintain, requiring frequent lamp changes as well as replacement of the rods as they deteriorate due to erosion from the continuous water flow. More serious are the fluctuations in amplitude and bandwidth due to unavoidable power supply ripple and water flow vibrations as well as instabilities due to changes in ambient conditions.

We propose to replace the oscillator with an actively mode-locked diode-pumped Nd:YLF system from Time-Bandwidth which has FWHM pulse duration of $\sim$8 ps. This would alleviate the need for the fiber stretcher as well as the compression gratings. As a result, the pulse length of the final output would be fixed at 8 ps for the IR (and $\sim$5 ps for the UV, i.e. $\sim$2 ps rms). This corresponds to our present operating conditions and longer UV pulses can be achieved by stacking.

Most recently, we have been operating the multipass with 7 round trips which corresponds to a gain of $\sim$3000. The new oscillator power is 400 mW at 81 MHz so the pulse energy $u = 5$ nJ. After amplification in the multipass, $u \simeq 15\ \mu$ J. For an area $A = 10^{-2}\mathrm{cm}^2$, and $\tau = 8$ ps, $I = 0.25$ GW/cm^2. Therefore the KDP Pockels cell in the multipass is still safe at this shorter pulse length. The 2-pass amplifiers provide a gain of $\sim$70 to bring the pulse energy to $\sim$1.0 mJ. Thus it is imperative to use at least a 2 mm beam radius into the 2-pass amplifiers so as to prevent possible damage of the glass rods.

We also foresee that the efficiency for conversion to UV will be improved to 10% by using refocusing between the two crystals. Thus the available energy in the UV, per pulse will be in excess of $\sim$50 μJ. Recall that for 1% efficiency the electron yield $\sim$ 2 nC/μJ. At some point we were concerned about the possibility of spectral hole burning due to the reduced bandwidth. Measurements with reduced bandwidth have shown that this is not the case.

In Table I we give the shot-to-shot fluctuations as measured in the present system and compare them to the expected fluctuations with the new oscillator. The physical location of the new oscillator is indicated in the sketch and would not preclude the use of the old oscillator if this became necessary. Pulse length measurements of the new oscillator can be carried out with our existing c.w. autocorrelator.

Quotations from three manufacturers are listed in Table II. We prefer Time-Bandwidth which has delivered operating units at Argonne and Brookhaven. The manufacturer will install the oscillator, but at additional cost. A possible concern is whether the environmental conditions in the laser room (especially vibrations) are adequate for satisfactory operation of the new oscillator. This problem is being investigated.

Table I

Present and expected shot-to-shot fluctuations (rms in %)

	Present	New Oscillator
Oscillator		
Amplitude	2-4	<1
Bandwidth	2-4	<1
After m-pass	7-9	4
After 2-pass	8-10	4
After compression	8-10	-
Green	11-15	4
UV in (laser room)	14-19	5
UV (cathode)	16-20	5
Pulse length	10-20	1

The fluctuations inside the pulse train should be at the 2% level if the time profile of the flashlamp voltage is appropriately tuned. The projected numbers are based on $dV/V \sim 0.2\%$ for voltage stabilization.

We also expect a significant decrease of the shot-to-shot space charge force fluctuation: from $20 - 30\%$ to 5%. We believe that the space charge force fluctuation is partly responsible for the beam's transverse profile fluctuation. (Note: space charge force fluctuation comes from the UV intensity fluctuation and pulse length fluctuation added in quadrutures).

Table II

Diode pumped oscillator quotes

Company name	**Time Bandwidth**	**High Q Laser**	**Alphalas**
Wavelength	1053 nm	1053 nm	1053 nm
Pulse duration	7 ps	6 ps	<8 ps
Jitter	<1 ps	<1 ps	<1 ps
Rep. Rate	80 MHz	81 MHz	81 MHz
Output power	400 mW	500 mW	500 mW
Power stability	<1% rms	<1% rms (24 hr)	<1% rms
Pointing stability	25 μrad/°C	—-	40 μrad
Beam quality (M^2)	<1.1	<1.2	<1.3
Price for laser	$58,500	$69,400	$42,450
Price for synch.	$23,500	$22,160	$18,060
Installation, training	$1,500	Included	$5,750 (optional)
Laser head	310 x 176 x 632 mm	430 x 200 x 80 mm	160 x 85 x 710 mm
Warranty	1 yr.	1 yr. (4000 hr)	1 yr. (3000 hr)
Shipping	$500	—-	$440

Upgrading to New Osc.